applying FORR to human/multi-robot teams

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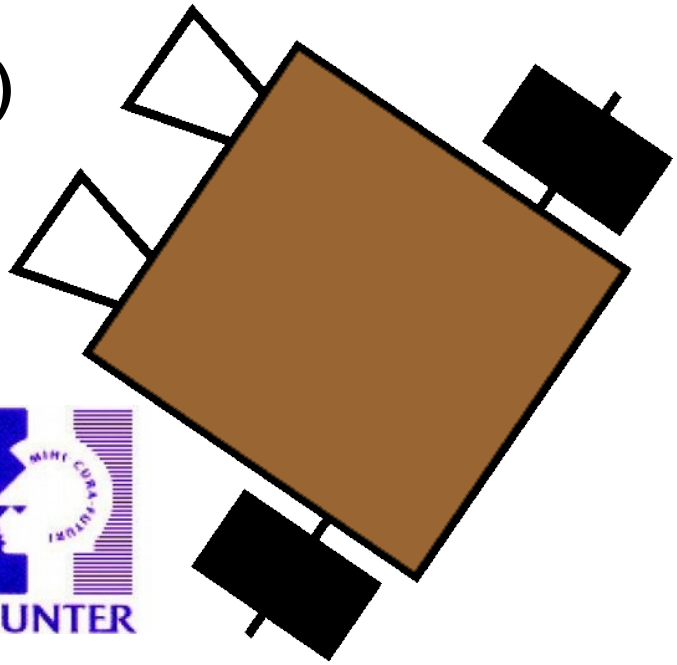
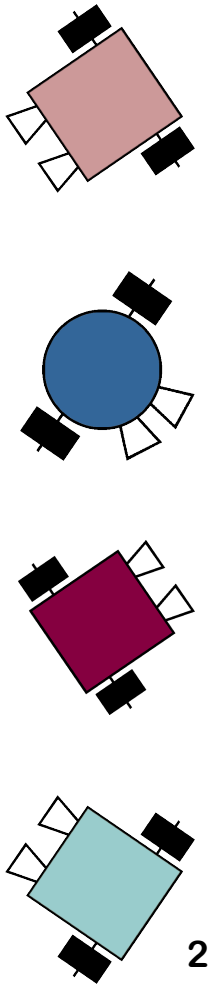


funding provided by the National Science Foundation

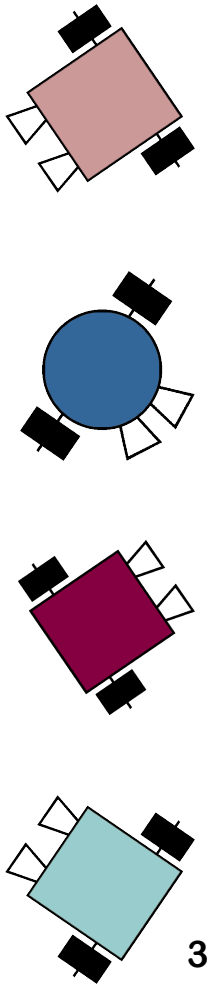
motivation: the big picture

- coordination of human/multi-robot teams, particularly in dangerous regions where human is not co-located with the robot team
- our "rough-and-ready" approach:
  - deploy heterogeneous team of low-end robots
  - distribute exploration tasks across team
  - inexpensive to replace a lost robot
- practical constraints present challenges:
  - camera quality is not great
  - processing is done either onboard (slow) or distributed (network dependent)
  - network connectivity is slow and intermittent



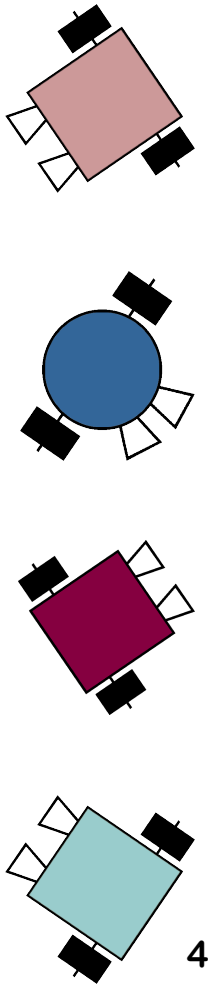
background: human/robot interaction

- modes of human-robot interaction:
  - human-controlled (*teleoperation*)
  - robot-controlled (*fully autonomous*)
  - collaborative control (*mixed initiative*)
    - » e.g., *adjustable autonomy*
- our approach:
  - robot collaborates with team of one human plus software agents and other robots
  - implemented using the ***FORR architecture***



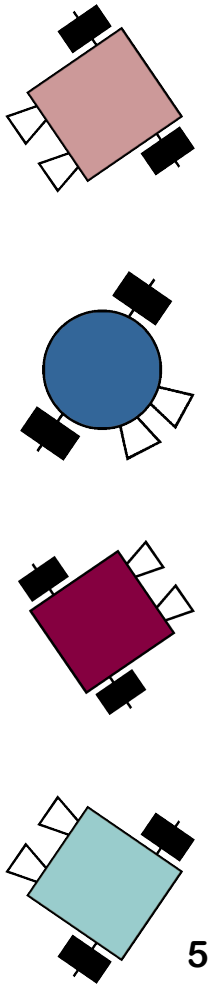
FORR architecture

- FOr the Right Reasons [Epstein 1994]
  - cognitively-plausible architecture that models the development of expertise
  - *domain-independent* architecture implemented with *domain-dependent Advisors*
- each Advisor is
  - resource-bounded procedure that represents a single rationale for decision making
  - considered in order of strength
  - voting resolves conflicts

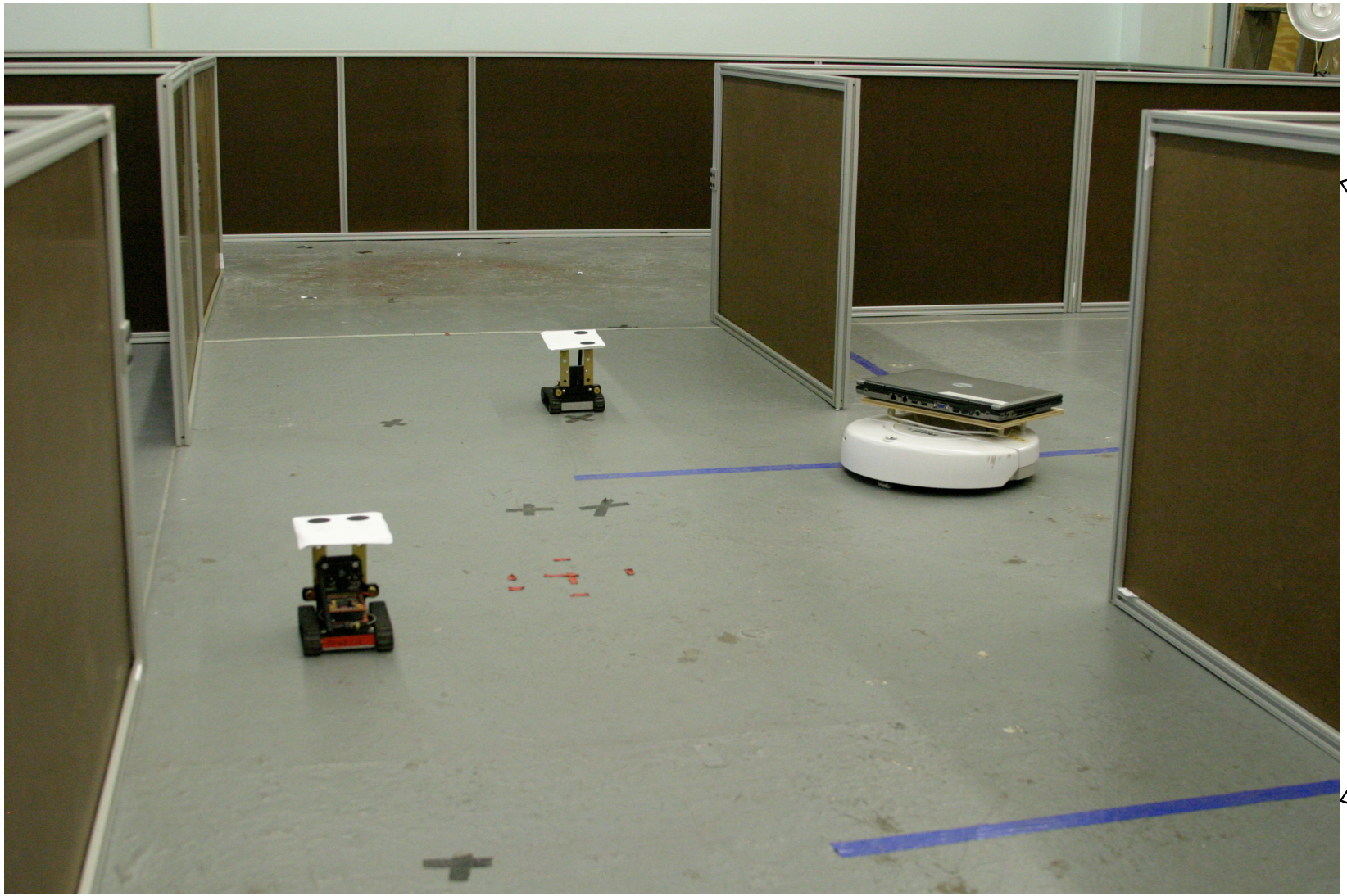


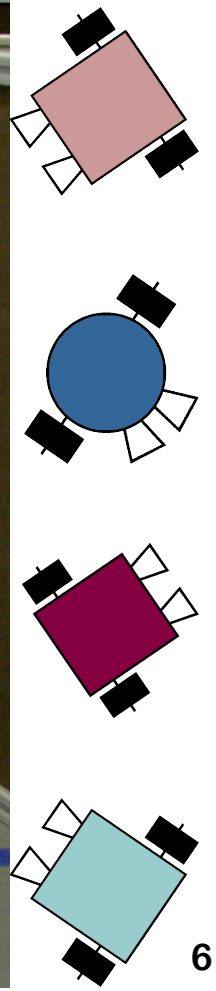
FORR applied to HRI domain

- previous FORR applications include:
  - game playing
  - simulated pathfinding
  - constraint solving
  - spoken dialogue
- *contribution:*
  - *application to physical robots*
  - *integration of human peer*
  - *shared advice across team*



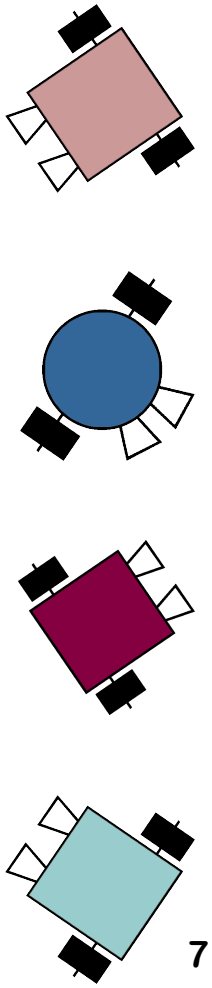
heterogeneous robot team in experimental test arena



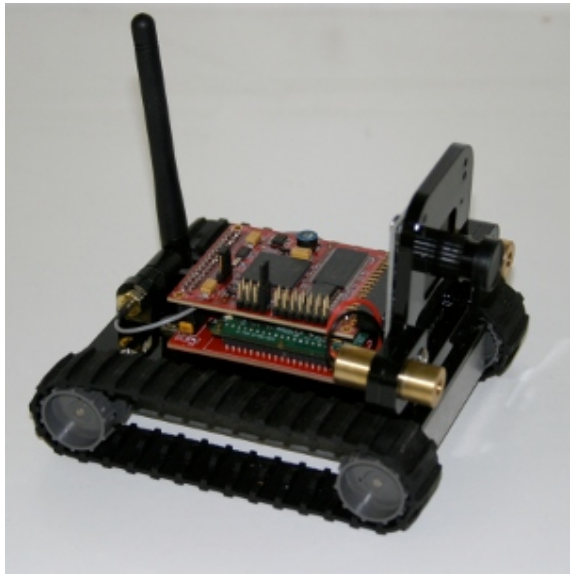


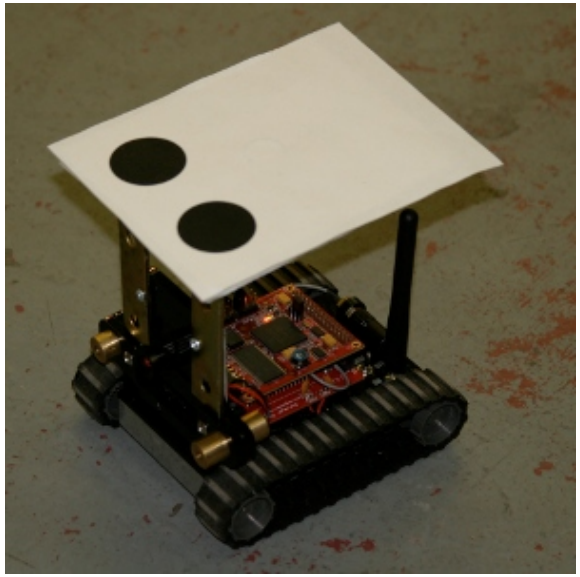
global vision system

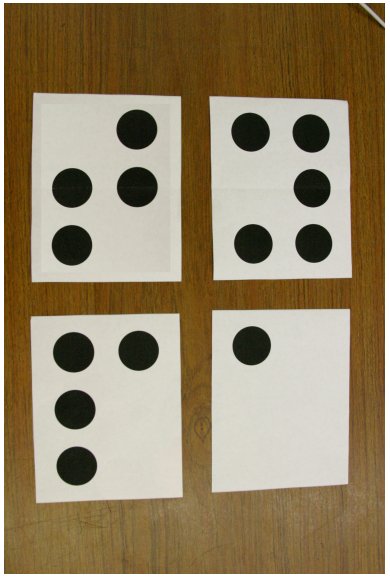
- simple *global vision system* combines multiple overhead cameras in a coordinated tracking system that follows the robots
- each camera finds 2-dimensional (x, y) coordinates and orientation (θ) of any robot (wearing a unique “hat”) in its field of vision
- each camera has its own agent-based process to find and track any robot(s) it sees, sending robot position and orientation to the central server
- cameras "hand off" robots as they move from one's field-of-view to another’s

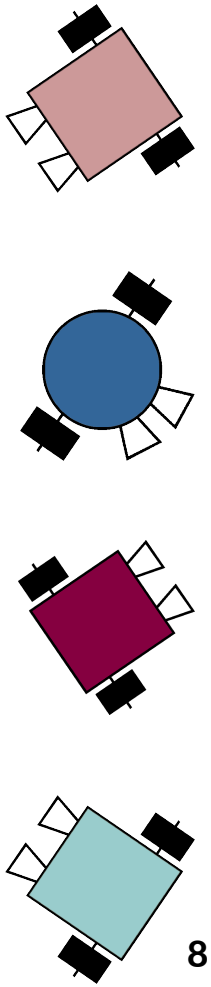


camera agents identify robots wearing "Braille hats"



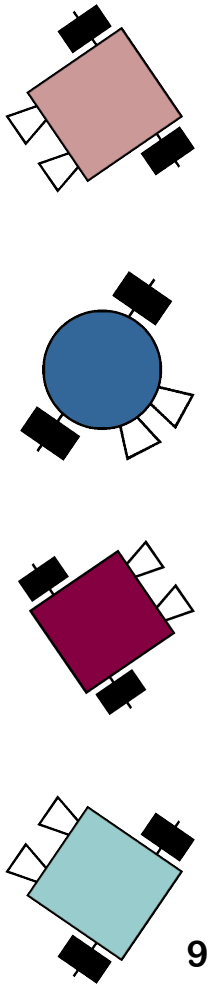




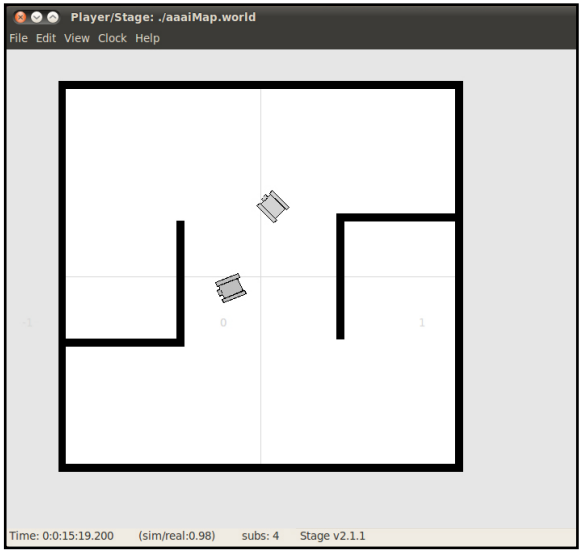


market-based task allocation

- *task points* are identified *a priori*
- system automatically allocates task points to robots in the team, using a simple auction mechanism:
  - robots bid their distance to the closest task point
  - uses A* algorithm to determine robot's path from current location (at time of bidding) to each task point

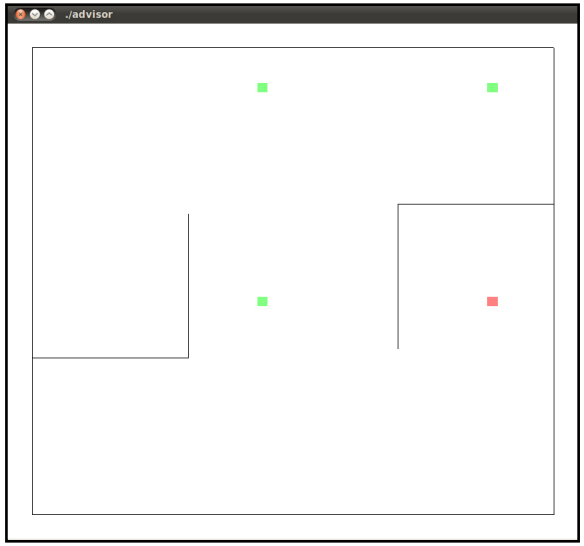


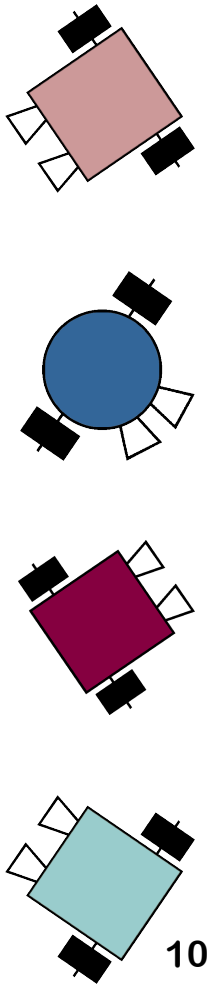
team-based exploration: simple example



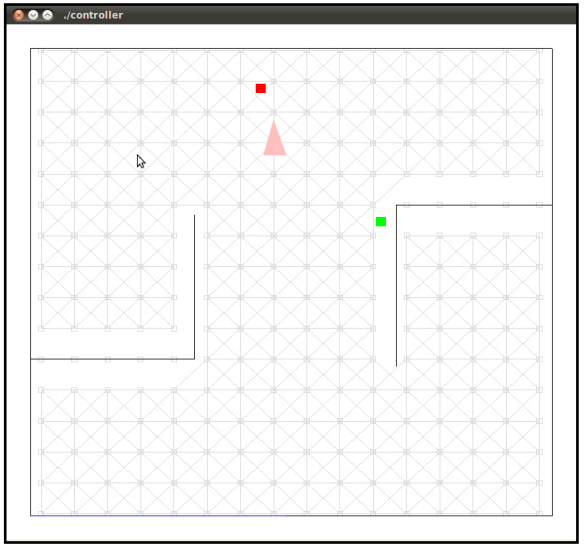
two robots in system

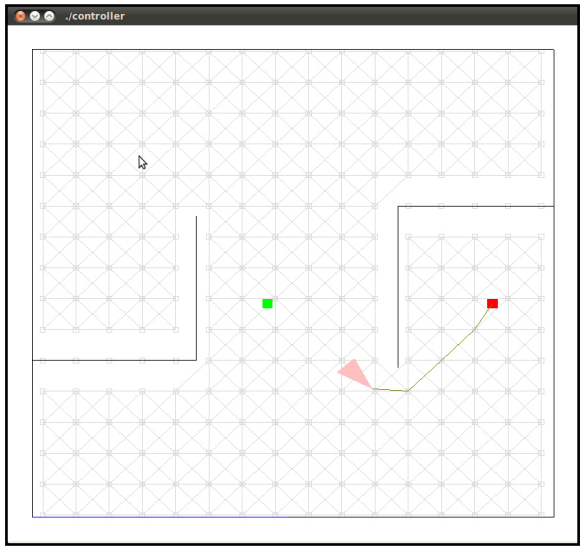
user clicks on task point(s)



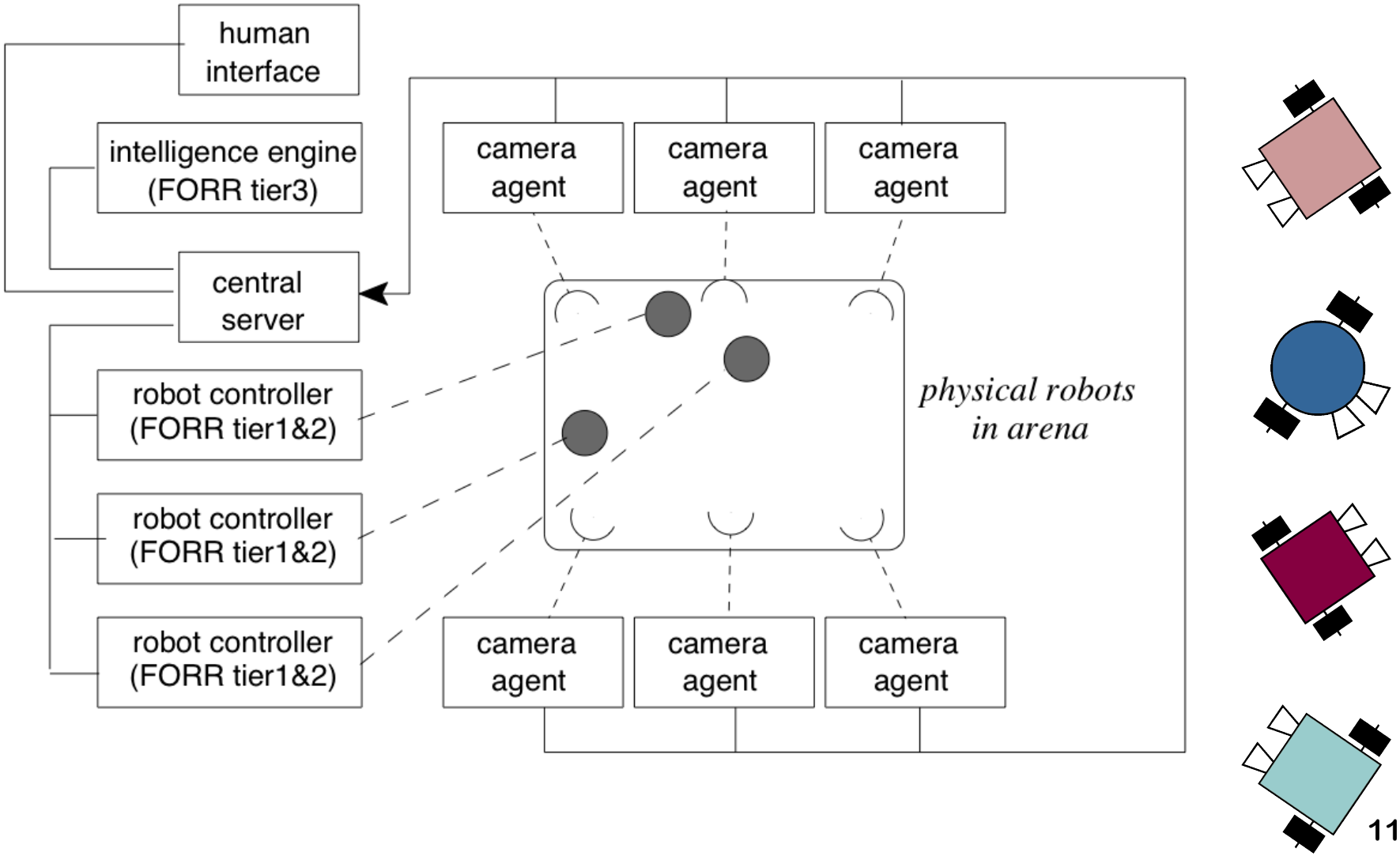


each robot bids on a task point and moves there when bid is won

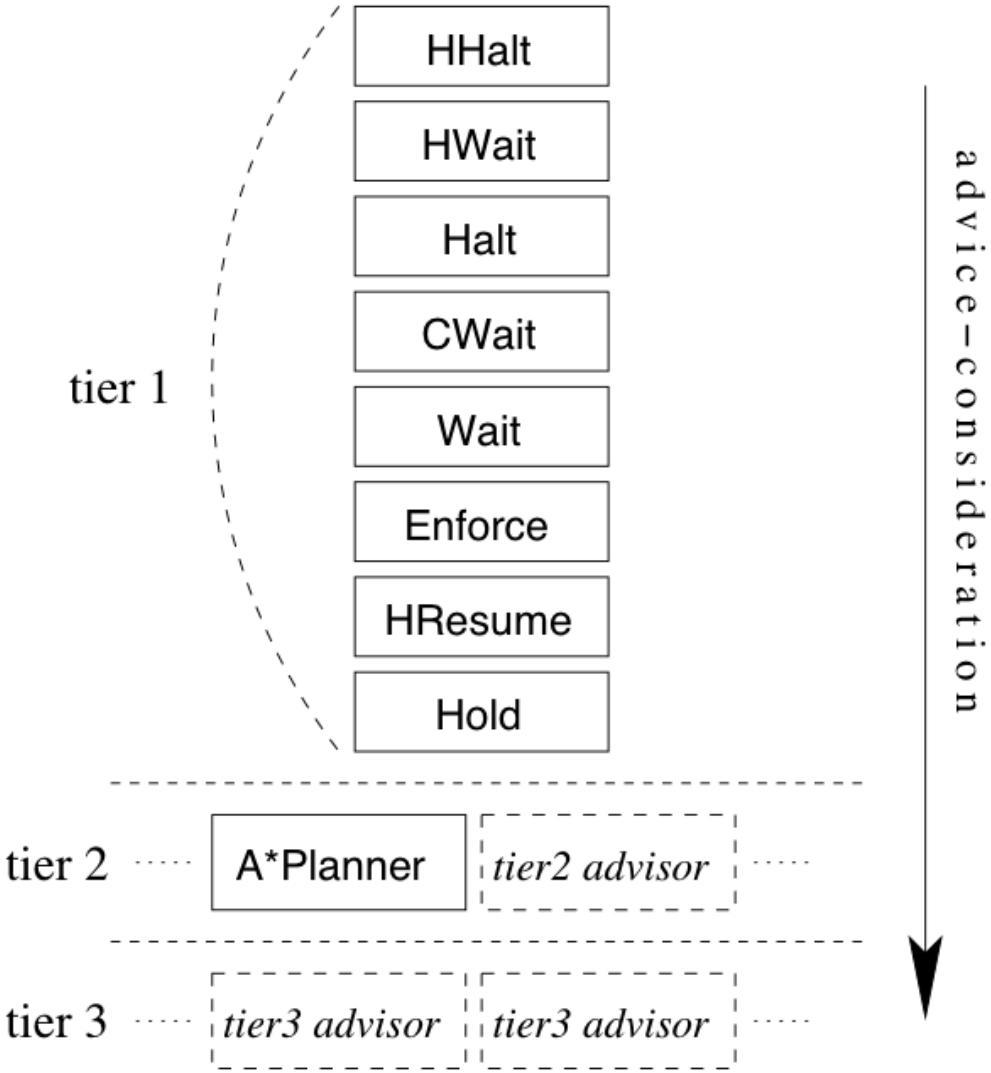


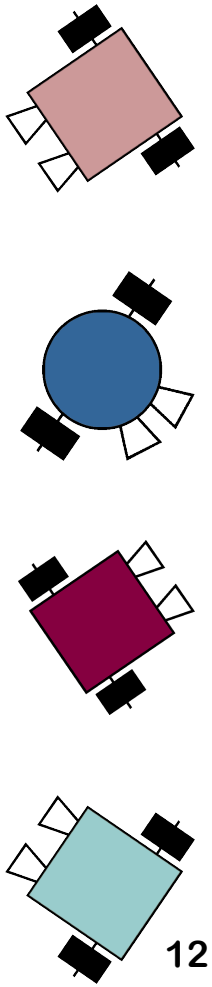


HRTeam framework



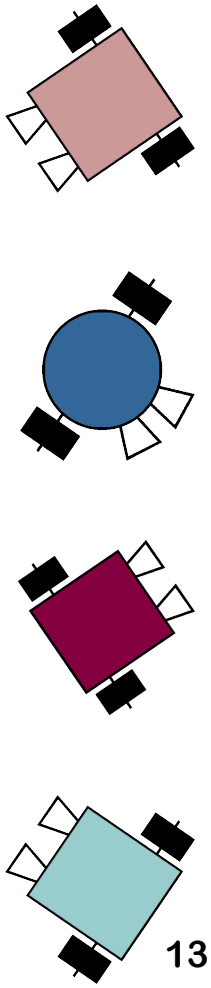
FORR Advisors, organized in tiers



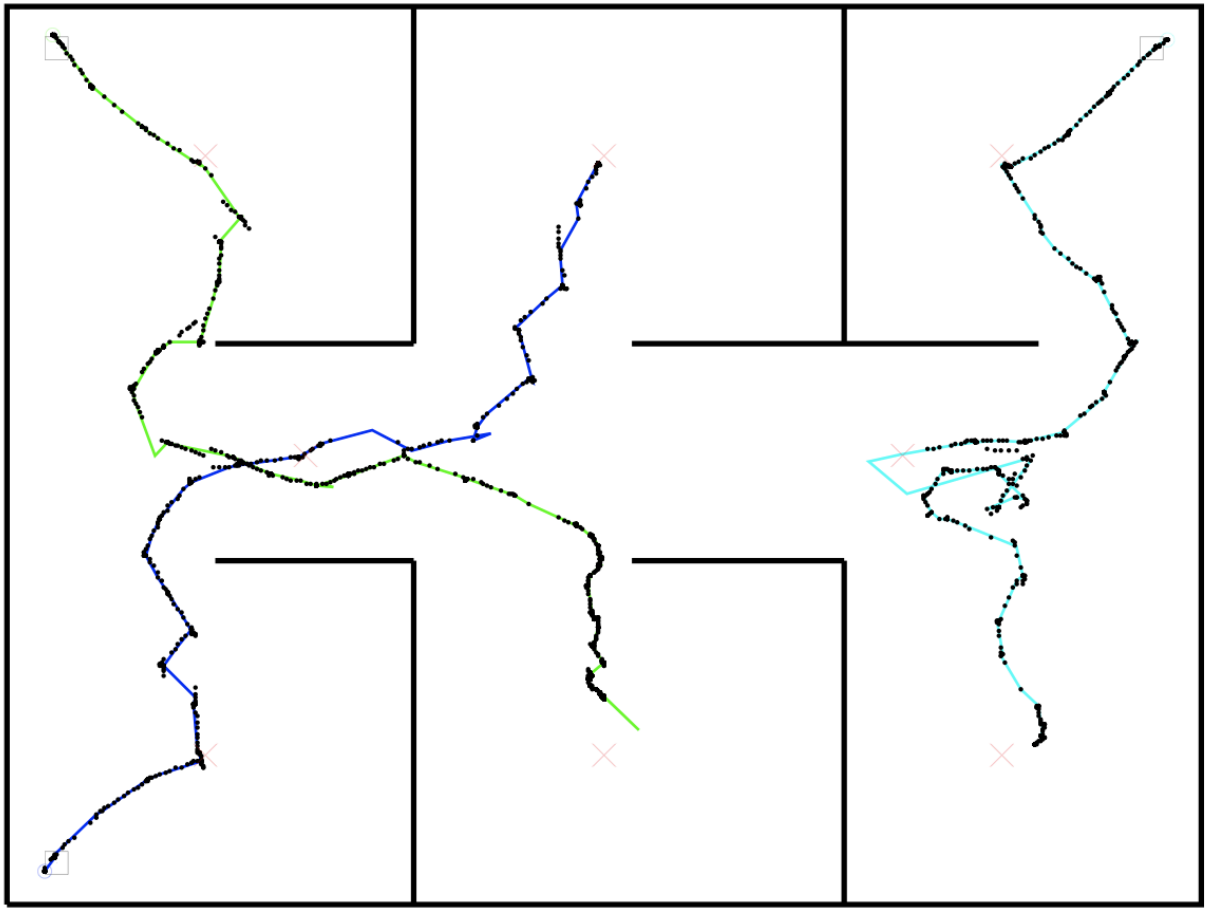


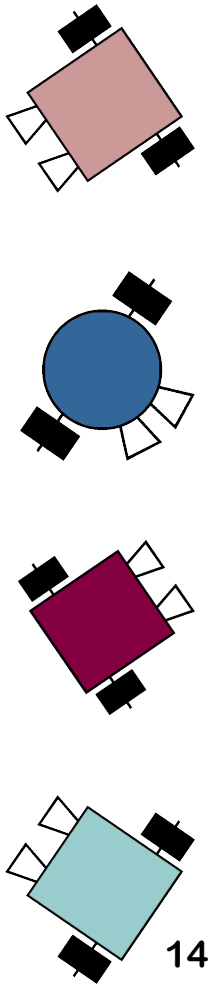
simple Advisors

- tier 1:
  - HHalt, HWait: input from human interface
  - Halt: system advocates stop (kill plan)
  - CWait: collision avoidance mechanism
  - Wait: system advocates pause (keep plan)
  - Enforce: system advocates next step in plan
  - HResume: input from human interface
  - Hold: wait for new plan
- tier 2:
  - A*Planner



experimental results forthcoming

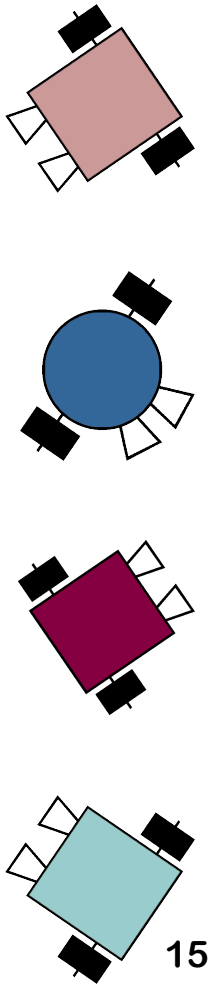




acknowledgments

- This work builds on contributions from many students, including:
  - Samuel Sanchez, Diquan Moore, Moses Kingston, Mark Manashirov, Joel Gonzalez

- This work was supported by grants from the National Science Foundation (#IIS-1117000, #CNS-0851901, #CNS-0520989).



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